NAVAIR's Coast-to-Coast Support of the E-2C Hawkeye Using Distributed TSP

Linda Lou Crosby
NAVAIR People, Process, Products, and Resources Team

Jeff Schwalb
NAVAIR Systems/Software Support Center Team

This article discusses the Naval Air Systems Command (NAVAIR) distributed team that became an example of how projects can work together remotely and be successful. This was accomplished through the use of common processes extended to multiple, distributed teams, their coaches, and the tools used to automate those processes. The other vital area addressed was the organizational cultures to be connected. This meant an important understanding of each other's assumptions, values, and styles needed to happen. This article is filled with observations and lessons learned from team members, team coaches, and organizational facilitators on the multi-site virtual merging of NAVAIR E-2C Hawkeye software developers at Patuxent River, MD with F-14D software developers at Point Mugu, CA.

The challenge facing the E-2C program at Patuxent River in Maryland in 2003 was one of simply having more work than the engineers could perform in the time allotted. At the same time, engineers at Point Mugu in California were working on the F-14D delivering its final block release to the fleet. When E-2C leadership discovered the available pool of engineers at Point Mugu, the question became one of how to successfully combine these two groups of engineers into one distributed team.

E-2C leadership at the time was aware of the F-14A/B/D model aircraft sun setting and the fact that many talented software engineers were becoming available for other work. The F-14 Integrated Product Team at Point Mugu saw working with E-2C as an opportunity to place their software engineers into a team with a bright future. F-14 leadership briefed the E-2C leadership on the capabilities of these software engineers as part of their effort to find a future home for them. Their Team Software Process℠ (TSP℠) credentials were so impressive that the E-2C program decided it was worth the extra effort involved in having virtual teams employed on their upcoming software development projects.

Members from the two sites became two integrated teams, one for the E-2C Mission Computer (MC) and one for the displays on board. The E-2C Leadership asked the NAVAIR Process Improvement (PI) enterprise team for an approach to establish this virtual software engineering team. They would start with TSP to establish a process engineering framework due to its success with other NAVAIR projects [1]. You will hear about three things in this article: TSP and its ability to support multiple, distributed teams, cultural change and how people were supported as the distributed team started, as well as responses about how this effort evolved and what they think of it now as they still continue to work together five years later.

TSP

To start, we will provide a quick review of basic TSP followed by the extensions of the multiple, distributed team version applied to E-2C. The basic TSP is a software engineering process framework created by the Software Engineering Institute (SEI) to help a team plan its work and then work that plan through collection of measures, regular communications, and replanning at milestones along the way to delivery of products [2]. The fundamentals are displayed in Figure 1.

The TSP starts by building a common language between software engineers on a team by training them in the Personal Software Process℠ (PSP℠) that they will each use [3]. This training uses both lectures and exercises so that engineers gain knowledge and experience in the use of the process scripts they will use, collection of basic measures used, and derivation of metrics from those measures so that project plans and actuals can be brought together to have quantitative project status on a weekly basis.

The beginning of the real project work is the launch [4]. It is a set of nine very structured and detailed planning meetings that start by communicating with project stake-

℠ Team Software Process, Personal Software Process, TSP, and PSP are service marks of Carnegie Mellon University.

F-14D Tomcat – United States Navy's primary maritime air superiority fighter, fleet defense interceptor and tactical reconnaissance platform from 1974 to 2006.

E-2C Hawkeye – Navy's all-weather, carrier-based tactical battle management airborne early warning, command and control aircraft for the Carrier Strike Group and Joint Force Commander.

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holders to obtain needs, wants, and desires. From this the team will proceed with identification of roles, goals, products, and services. Then they proceed with the top-down and bottom-up plans necessary to have each member of the team own a balanced workload of tasks that allow two to four tasks to be accomplished each week. This way, when the team becomes operational after launch each person is able to know if they are making progress or if they need to shift tasks with their teammates.

While Figure 1 shows a launch happening at requirements time, a project may actually start TSP anywhere in its life cycle based upon the next opportune time to do so. For example, if a project wishes to apply TSP for the first time and is currently developing requirements, then it will obtain the TSP training sometime shortly before the high-level design phase and then launch after requirements are complete.

Another feature of TSP is planning an entire project from top-down at the beginning and then re-planning as milestones along the way are reached. This is because the level of detailed planning done in TSP should not exceed three to six months due to reasonable horizons of work being done and the idea of working from milestone to milestone. While Figure 1 shows a simple waterflow model, a team may instead choose other strategies where example project cycles develop iteratively functional versions of a project. A typical multi-year project will go through several cycles of bottom-up planning as it moves from one milestone to the next.

Distributed Team

To recap, the E-2C program was doing two things with TSP. It was using *multiple* project teams to deliver its product and in virtual teams that were *distributed* between Maryland and California. Each project team is self-coordinated, with each member acting in one of several technical, support, or lead roles that coordinates all these efforts. Each of the E-2C project's leads, planning coordinators, and quality coordinators would come together in key parts of a multi-team launch. Planning coordinators came together before and after top-down and bottom-up plan meetings to check status and test any assumptions. Quality managers meet after the quality plans have been generated to do the same. Also, at the end of each day of launch the leadership team, consisting of each project lead and the coaches, convene to check status and discover any horizontal issues that may affect each other.

Shown in Table 1 is recent data from the E-2C distributed team plans. Teams were constructed based upon expertise and interest of engineers. The E-2C teams as shown have a good handle on their plans and products. These teams effectively planned their work every four to six months to the level of granularity as described previously. These launches were conducted with the smaller portion of the team typically traveling to allow the entire team to get together. This face-to-face planning style was vital to maintaining trust in the virtual team.

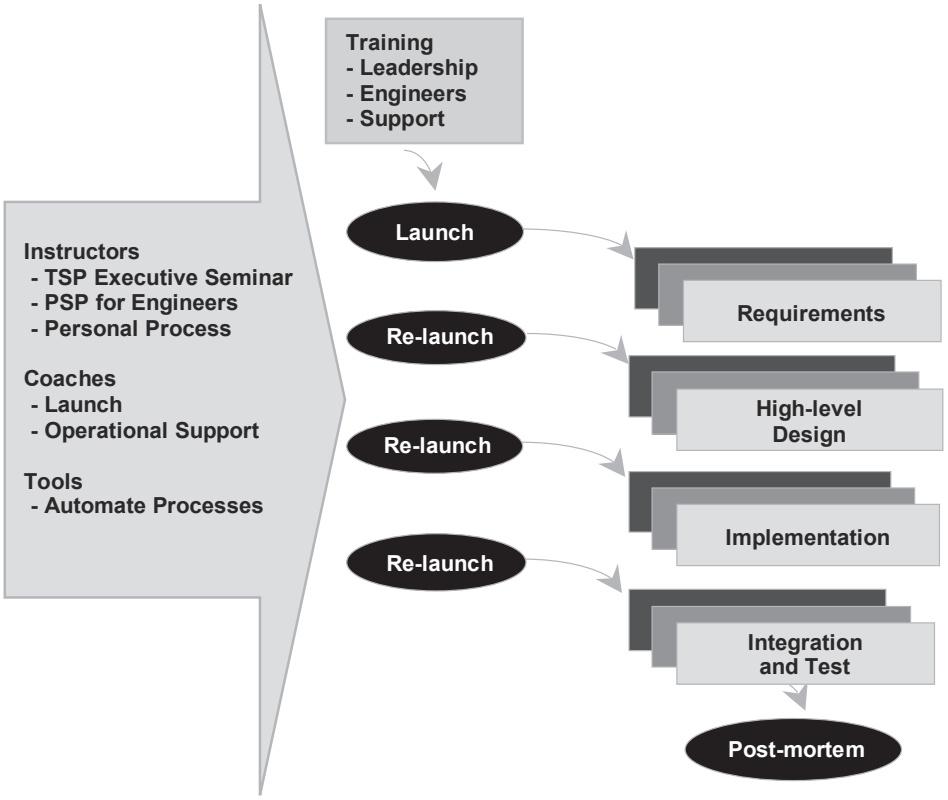

Figure 1: *TSP Approach of Training, Planning, and Operations*

Operationally these teams know where they are with ongoing weekly communications via teleconference. These teams chose to break up their weekly communications. The first is a TSP data-driven meeting to track progress, as shown in Table 2 (see page 6). The other weekly teleconference meeting is used to discuss technical issues. The key is that these teams are planning their work and then working those plans for constant improvement.

Cultural Change

To address the culture change needed to join the two teams, the NAVAIR Organizational Development (OD) team would work the people issues as the PI team focused on processes. NAVAIR sites had traditionally been perceived as competitors to each other; this is a difficult barrier to break down as many of our working systems still support this perception. Also, the folklore within each site includes stories of past competition. We needed new stories of successful collaboration to replace the competition stories. This team saw the possibilities and we built on that.

Part of the challenge in this effort was the culture ingrained at each NAVAIR site. A Software Support Activity (SSA) maintains and delivers the software needed to bring high tech capabilities to today's advanced aircraft. Without software, the aircraft would be

Table 1: *E-2C Distributed Project Teams*

	Team Members		Project					
Project Type	Pax	Point Mugu	Tasks	Weeks	Tasks/ Eng/ Week	Cycle Complete Date	Hours (planned/ actual)	Earned Value (planned/ actual)
A	8	4	780	16	4.06	12/2006	1.97	1.37
A	8	4	800	24	2.78	7/2007	0.95	1.22
B	4	12	1788	24	4.66	12/2006	1.13	1.18
B	4	12	1713	24	4.46	5/2007	1.12	1.06

A=Advanced Control Indicator Set B=MC

❑ What's happening outside the project?
❑ Each role coordinator reports
❑ Goals
❑ Risks
❑ Project status (plans vs. actuals)
❑ Upcoming tasks and special events

Table 2: *Weekly TSP Team Meeting Typical Agenda*

unable to deliver today's precision weapons. Traditionally, members of an SSA were co-located because all had to be close to the simulation/test lab where they produced/modified the software and tested it. For example, F/A-18 and AV-8B at China Lake, F-14D at Point Mugu, E-2C at Patuxent River, MD, and so forth. With the advances in technology, the availability of high-speed communications lines has gone up and costs have lowered, allowing virtual teaming to become much more common. If anything, it is now the culture – norms, customs, traditions – that seem to stand in the way of increasing the use of virtual teams.

E-2C leadership announced from the start that the teaming arrangement would not be one of developer and subcontractor, but rather a single integrated team – a true partnership. One benefit from this partnership is increased resources. Pax needed more engineers and Point Mugu needed more work. Without that relationship, they would not have been able to give the fleet all the wanted and needed functionality – the benefit being that E-2C would generate more work for itself and help the program grow. In the end, the program thought it could be used as an example to follow when considering a successful multi-site team.

According to the OD team, the challenge was pretty clear: NAVAIR has been producing software-intensive products for decades so the knowledge for software exists with the people all across the NAVAIR sites. Bringing teams together, rather than hiring new people into a site, is more efficient because the cost of recruitment and training is not needed. Instead, the investment is made in building a team rather than in training in the software domain. The people who came together on this team already had the NAVAIR knowledge and knew how to develop good quality software. They just needed to learn how to work together from across the country.

Team Building

Building the virtual teams was accomplished with two initial events. The first was a three day initial gathering in June 2003 designed to start the building of a new common culture. Its objectives were the following:

1. Get every team member to meet and greet, get to know each other, and have some fun.
2. Share history of each subgroup and establish a vision of the future for this newly formed team.
3. Establish team operating principles and obtain team agreement on basic operations.
4. Identify communications methods and processes for initial team operations.

To meet these objectives, the first day was conducted as a set of outdoor activities to get everyone to know each other and have fun. Activities were conducted in a park on base at Pax and included various games such as the following:

- Celebration of success – developing ways to do so.
- Reflection – what in your past will contribute to success.
- Picture cards.
- Ah-So-Koh circle.
- Newspaper talk – sharing information.
- Climbing wall.
- Hula hoop lift.
- Reflection – personal plan, etc.

Table 3: *Individual Feedback*

Project	Location	Comments
Mission Computer	Point Mugu	Team building was valuable: "Although some distrust levels were still around after the team building event, the event lay the foundation for the groups to build a functional team to achieve the common goals."
Foreign Military Sales	Point Mugu	Had his doubts initially but realized E-2C was serious: "…when I saw the effort going in at PAX to provide the training, tools, and resources necessary to get the job done here at Point Mugu, I knew management was really supporting this."
Mission Computer	Point Mugu	Results were the key: "After successfully delivering many projects within schedule for the Version-5 fleet release, I realized that the *distributed approach* was going to work. If people did not work together as a team to solve problems, they simply could not achieve such results. Since it was the first project, working together to deliver Version-5 was the most difficult. Several projects after that were flying smoothly."
Display	Pax	Attributes team success to TSP. Has been a team member since March 2004, develops requirements and detailed design documentation: "TSP provides organization and communications; as a developer, you know exactly what is expected from you from the start of the project. Both managerial and team expectation. In order to accomplish those objectives, you need to have strong communication within the teams."
Mission Computer	Point Mugu	Technology was an issue: "I think the biggest challenge was and is operating a classified network across the country. Not so much because the technology is not there, but because of all the security hoops that we have to go through to get our network approved."
Leadership	Pax	Technology also helped: "Technology aided in allowing this team to work together. We were able to establish a network across country, which allowed the use of a common data repository and common processes to be used. For example, everyone at both sites used the same configuration management system."
Display	Pax	Had previous experience on a distributed team, and did not like it: "It was not well coordinated and I always felt like we were the *poor-stepchildren* in the process." This time the approach was completely different: "There is high coordination and management attention to the issues involved technically in making it work smoothly. I know that this time I am on the big side (East Coast) and so that may make things different, but I think that there is much more sense that the West Coast folks are *real* team members, not just hired help."
Mission Computer	Point Mugu	Importance of communicating across the sites: "The biggest challenge was communication. Several conference calls and meetings between the two sites took place. Several visits were made by team management so they could know every team member and build the bridge between them. These efforts definitely helped."

The second and third day events were conducted indoors with the goal of increased understanding through historical and present-day perspectives. Many of the outcomes of the games and adventures of the first day would be available for use in this second and third day of team building. Activities included the following:

- Team introductions.
- Team history.
- E2C lab tour.
- Myers-Briggs Type Indicator workshop.
- Strengths/weaknesses/opportunities/constraints chart developed by the team.
- Gap analysis determined, solutions proposed, and actions assigned to team members.
- Team members built joint vision for the future.
- Team members drafted team agreement, mission, and vision.

The second event was performed about eight months into the projects in February 2004. A follow-up with E2-C project teams was performed by conducting confidential interviews at both sites. From topics that emerged, a set of team-building topics were presented to team leaders for possible follow up. One of the most impressive discoveries from the confidential interviews was that communication between the two sites and team members was going well – a big plus!

Observations

While engineering process and cultural change were important in making this E-2C multi-distributed team get started, we were most interested in the people themselves and what they thought. With evolving requirements and launches accordingly, these projects still exist and operate in very much the same distributed way as they started nearly five years ago. While that says a lot, we wanted to know what real participants said (see Table 3).

A member of one E-2C team did a good job showing some of the fundamental places where PI and cultural change (see Table 4) took place. Individuals of a team located in different places must know and trust each other to plan their work and then track it. To do so, historical data must be collected and used for tracking and improved planning.

Conclusions

It is important to understand that real people are the key to any technology improvement being successful, especially when it is a distributed team. The important thing for readers to realize is that their situation could accomplish the same great success with the buy-in of people from their organization.

1.	**Have a project plan.** Everyone should know the mission and goals. Each member should know who is responsible for what and when.
2.	**Learn about available resources from each other.** How many developers are available and what skills or talents does each individual have? What equipment and tools are there for development and testing?
3.	**Communicate with each other and communicate often.** Plan weekly meetings, plan face-to-face meetings, e-mail, and call often.
4.	**Trust each other.** Team members should respect and understand each other.
5.	**Share information.** Team members should share what they know and what they learn with everyone else.
6.	**Work to your plan and goals**.

Table 4: *Six Factors That Produce Success for a Multi-Site Team*

The immediate result was the F-14D engineers were given a new lease on life, while E-2C welcomed some incredibly well-versed and knowledgeable people into their program. Long-term results (continued excellence in delivering software products to the Fleet) show that people with similar training and skills can move *laterally* in an organization and continue to make a solid contribution. Finally, the overall experience shows that two separate organizations must remember the importance of considering cultural factors when bringing teams together.

As for the future, it is full speed ahead, and more of the same for the E-2C multi-site team. With initial concerns a thing of the past, the E-2C team can fully focus on the *Hawkeye* mission. E-2C is right on target and they set a great example for others to follow in proving that *miles don't matter* when it comes to having a successful Integrated Product Team.◆

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About the Authors

Linda Lou Crosby has chronicled software process and organizational improvement at NAVAIR since 1999. Previously, she produced and reported for KCET Public Television in Los Angeles (including an Emmy nomination), wrote an award-winning column, and has created award-winning videos for the U.S. Navy. Crosby is presently working with the Center for Risk Communication and the People, Process, Products, and Resources team at NAVAIR.

NAVAIR
People, Process, Products, and Resources
Code 41E000D
1900 N Knox RD
BLDG 1494 MS 6308
China Lake, CA 93555-6106
Phone: (760) 377-5001
E-mail: LI_neon@iwvisp.com

Jeff Schwalb is employed by NAVAIR at China Lake, California. Currently, he works in an enterprise team that helps provide continuous process improvement support across NAVAIR. Schwalb has taught each of the TSP/PSP courses many times and has been involved in the TSP launch of several projects across NAVAIR. He is now working with SEI to extend TSP practices into other domains. Schwalb received his bachelor of science degree in computer science from California State University, Chico in 1986.

NAVAIR
Systems/Software Support Center
Code 414300D
1900 N Knox RD
BLDG 1494 MS 6308
China Lake, CA 93555-6106
Phone: (760) 939-6226
E-mail: jeff.schwalb@navy.mil